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Inclusive Charmed-Meson Production at the CERN LHC

B. A. Kniehl[1], G. Kramer[1], I. Schienbein[2] and H. Spiesberger[3]

[1] II. Institut für Theoretische Physik, Universität Hamburg,
Luruper Chaussee 149, D-22761 Hamburg, Germany

[2] Laboratoire de Physique Subatomique et de Cosmologie,
Université Joseph Fourier Grenoble 1,
CNRS/IN2P3, Institut National Polytechnique de Grenoble,
53 avenue des Martyrs, F-38026 Grenoble, France

[3] Institut für Physik, Johannes-Gutenberg-Universität,
Staudinger Weg 7, D-55099 Mainz, Germany

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Abstract

We present predictions for the inclusive production of charmed hadrons at the CERN LHC in the general-mass variable-flavor-number scheme at next-to-leading order. Detailed numerical results are compared to data where available, or presented in a way to ease future comparisons with experimental results. We also point out that measurements at large rapidity have the potential to pin down models of intrinsic charm.

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1 Introduction

Past measurements of charmed-hadron, X_c, production in high-energy scattering experiments [1] have shown that inclusive heavy-quark production provides us with an interesting testing ground for the dynamics of the strong interaction. With the advent of high-statistics data from the LHC, we can expect that upcoming new results will allow us to test the predictions of QCD with much better precision. The LHC experiments will also extend into the region of higher transverse momenta, where theory is expected to provide more reliable predictions. This is not only important for testing QCD itself; but a good understanding of heavy-quark production is also vital for searches of new-physics phenomena.

Recent analyses of D-meson production at the LHC have been published by the ALICE [2] and ATLAS collaborations [3]. Similar data that are being analyzed by the LHCb collaboration [4] are expected to appear soon. The aim of the present article is to present predictions for the inclusive production of charmed hadrons at the LHC within the general-mass variable-flavor-number scheme (GM-VFNS). We extend results which have already been used by the experimental collaborations for comparisons with their data, and we discuss these results under a common perspective. Where possible we, therefore, use information from the experiments about the accessible phase space regions. In a recent paper [5], we have considered the inclusive production of B mesons, for which experimental results from the CMS collaboration are already available [6, 7, 8].

Theoretical predictions for the production of heavy-flavored mesons at high transverse momentum (p_T) are technically difficult to obtain due to the presence of two different scales, p_T and the heavy-quark mass m. On the one hand, the heavy-quark mass can be considered as the large scale, since $m > \Lambda_{\rm QCD}$, making perturbative QCD applicable. When m is the only large scale, as for example in the calculation of the total cross section or in predictions for p_T distributions at small values of p_T, i.e. if p_T is of the same order of magnitude as m, predictions from a fixed-order calculation are reliable. On the other hand, if the transverse momentum of the produced heavy quark is large compared with the heavy-quark mass, $p_T \gg m$, then large logarithms $\ln(p_T^2/m^2)$ have to be resummed.

In the first case, for $p_T \lesssim m$, the traditional approach is called fixed-flavor-number scheme (FFNS) [9]. It is based on the assumption that the gluon and the light partons (u, d, s) are the only active partons. The heavy quark appears only in the final state, produced in the hard-scattering process of light partons. The heavy-quark mass is explicitly taken into account together with the transverse momentum of the produced heavy meson assuming that m and p_T are of the same order. Predictions of the FFNS are reliable close to the threshold of heavy-quark production.

In the second case, for $p_T \gg m$, the large logarithmic terms have to be resummed. The well-known factorization theorem provides the foundation of this resummation by incorporating the large logarithms into parton distribution and fragmentation functions and imposing the DGLAP evolution equations. This approach requires that the heavy